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LASER ENABLES A BETTER VIEW OF SPACE

KIRTLAND AIR FORCE BASE, N.M. – Ask any astronomer how to get a quality image of an object in space and he or she will tell you that it's through a good telescope and good weather. Ask a scientist at the Air Force Research Laboratory's Directed Energy Directorate and he or she will agree that it's through a good telescope and decent weather, but true quality is only achieved with adaptive optics.

"You could have a 100-meter (328 feet) mirror on a telescope, but without adaptive optics, you will get the same image resolution as an off-the-shelf 4-inch telescope. You just cannot get the full use of the aperture without adaptive optics," said Lt. Col. Dennis Montera, chief of the analysis branch at Starfire Optical Range.

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Adaptive optics (AO) refers to optical systems that are able to compensate for optical effects, such as the twinkling of stars caused by air turbulence between the ground and space, leading to better imagery. With better images comes better resolution and object brightness, and for astronomy, where light levels are often very low, this means fainter objects can be detected and studied.

The Starfire Optical Range, a world-class optical research facility of the Laboratory's Optics Division located at Kirtland Air Fore Base, N.M., is outfitted with a premiere adaptive optical telescope capability. The primary mission of the range is to develop optical sensing, imaging, and laser propagation technologies to support Air Force aerospace missions.

The Optics Division is capable of conducting research to improve optical and imaging systems, as well as developing technologies to accurately propagate laser energy through a turbulent atmosphere. The division operates the largest and most sophisticated telescope facilities in the Defense Department, conducting experiments at the Starfire Optical Range on Kirtland Air Force Base, North Oscura Peak on White Sands Missile Range, and at Hawaii's Maui Space Surveillance Site.

Much of today's adaptive optics, using laser guidestar techniques, was pioneered at Starfire, leading the development for military and civilian astronomy needs. The laser guidestar method uses a laser fired into the upper atmosphere to create an artificial star. The light from the artificial star received back at the telescope allows measurement of the distortion. Adaptive optics is then used to deform a mirror, to compensate for the turbulence, and enables scientists to get a sharper view of objects.

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Craig Denman, a physicist with the directorate's Laser Division, and his team led the development of a revolutionary all-solid-state sodium guidestar laser technology, a technology that can potentially help ground-based imagery surpass even that of the Hubble Space Telescope. The sodium laser is projected into the night sky, exciting a layer of sodium atoms in the upper atmosphere – creating a very bright yellow light source that is used with AO to view space objects.

"The Air Force Research Laboratory has pioneered the development of new AO technology and seen its use worldwide. Beginning as far back as twenty years ago, there was a need for the sodium guidestar laser. In the early 1990's, the Massachusetts Institute of Technology successfully developed a yellow photon solid-state laser for the Air Force Research Laboratory but it never made it to the telescope because it was not compact enough," said Denman. "The first guidestar lasers used dyes as the lasing gain media and were very expensive and hazardous. We devised, in-house, the first computer-automated all-solid-state sodium guidestar laser system that would work with Starfire's 3.5 meter telescope and achieved 50 watts of continuous-wave power."

The success of the technology, coupled with the adaptive optics built into the Range's 3.5-meter (about 11.5 feet) telescope can be measured as 10 times more efficient photon return from the mesospheric guidestar with five times more power than other systems. Though, Denman said, "we are learning as we go."

Adaptive optics and guidestar technology at the laboratory was initially for defense and military applications, but the research also benefits the astronomy community. Scientists at the Laboratory share learning and information with those in the astronomy industry.

"The Air Force can spend time studying the intricacies of how to make guidestars better. It costs so much to do astronomy on the big telescopes that astronomers can't afford to do the more time-consuming laser and guidestar scientific studies that we can. It's a nice marrying because we both get to learn in the long run. It's a symbiotic relationship," said Denman.

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Equipment at the Starfire Optical Range includes a 1.5-meter (about five feet) aperture telescope, a one-meter (about three feet) aperture beam director, the 3.5-meter telescope and smaller telescopes used for atmospheric measurements. The workforce includes approximately 30 military employees, 30 government civilians and 60 on-site contractors.

The 3.5-meter telescope that uses the sodium laser is 35-feet-high and weighs approximately 275,000 pounds. Through a series of mirrors the light travels from the telescope to a central optics room housing primary adaptive optics and a tracking system. From that point, the compensated or uncompensated beam can be sent to any one of four optical laboratories.

By the end of the year, Starfire should also have its own mirror coating capability at the site's Telescope & Atmospheric Compensation Laboratory, which opened in 2004.

Cooperative research agreements with other observatories such as Gemini and WM Keck have been conducted from time to time to further astronomy research and Air Force technologies.

"Our work toward improved sodium guidestar excitation sources and understanding better the sodium guidestar physics can benefit the astronomy community. By helping them, it helps us to do the work necessary to improve our own systems as well," said Denman.

It's a relationship, it seems, written in the stars.